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Tittel

The Nord-Østerdalen Project 1990

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Råstoffgruppe	Råstofftype
Malm/metall	Cu Zn

Sammendrag, innholdsfortegnelse eller innholdsbeskrivelse

Rapporten er et forslag til geologiske undersøkelser for 1990, men den inneholder også en geologisk beskrivelse og oppsummering av tidligere arbeider som er gjort i området.

Forekomster som er beskrevet og foreslått videre undersøkt er:

- Sivilvangen
- Svartåsen
- Vardtjønn
- Nosvola
- Fådalen - Tonnvola
- Området mellom Vangroftdalen og Langen
- Nord og syd for Folla
- Vesleåsen
- Tunndalen

NB mangler fig 3, 4, 5

Original

THE NORD-ØSTERDALEN PROJECT

1990

– a suggestion.

Terje Bjerkgård

February 1990.

1. Introduction.

This report is a suggestion to a new exploration project in Nord-Østerdalen, informally called the Nord-Østerdalen project 1990. The report is a result of work done by Folldal Verk A/S, but consultating prof. Arne Bjørlykke at the University of Oslo.

The area which is of interest extends from Os in the north to Alvdal in the south and is limited to the volcanic Hersjø Group (fig.1). This unit extends from Meråker in the north to Folldal in the south (under different names however).

Massive Zn-Cu sulfide deposits are found throughout this unit, including the large Killingdal and Folldal deposits. The suggested project are concentrated to a smaller, not very well investigated area, to try to find new deposits of this kind.

The project will be a continuation of the Folldal Project (project N-81-1) which covered a larger region, but which also included the suggested area.

This report is made from a new study of the data collected in connection with the Folldal Project. The data includes regional geophysics and from this ground geophysics, geochemistry, mapping and drilling have been done in selected areas.

From these data more work are recommended on a few old targets. A few new targets have also been found from the regional geophysics, in connection with stream sediments taken in the late 1960's.

2. Selection of targets.

The Hersjø Group volcanics have been created in an island arc and back-arc basin environment. This explains the very high amount of felsic volcanics and both felsic and mafic tuffites which is found. In such environment sulfide deposits are often connected to felsic volcanics (e.g. Kuroko deposits in Japan). Because of the high viscosity, these rocks will not flow a long way from their vent and they will therefore make up domes. Between the domes there will be low areas, at some places basins. These areas will be filled with tuffites and in deeper parts also sediments which may be graphitic.

Regional geophysics in the Os-Alvdal area (magnetics, EM, VLF) are showing long formational conductors. Mapping shows these conductors to be related to graphite. Where these conductors stops, an area of magnetic low and high resistivity is often found. This is often found by fieldwork to be felsic volcanics or intrusives and may correspond to a volcanic center, especially if the felsic rocks makes up a thick unit (i.e. dome structure). Eventual short conductors within this area may be caused by sulfides. To summarize; targets to follow up have been selected from the following criteria:

Regional Geology.

a) Thickness of volcanics, preferably felsic.
b) Trondhjemitic intrusions in the area. Several of the known mineralizations have associated such intrusions, even though their relationship to the sulfides and/or volcanics are uncertain.

Regional Geophysics.

a) Break in long formational conductors.
b) High resistivity.
c) Low magnetics.

These factors combined with positive geochemistry (stream sediments) makes a target to follow up.

3. Results.

The above described working model picks up several interesting targets, of which some have been worked on before. Unfortunately, the method does not work on distal mineralizations like the Sivilvangen and Vingelen deposits.

The philosophy behind the study of the ground data from the Folldal Project this time, has been to connect geology, wallrock alteration and mineralizations in the different areas to try to find possible extent of mineralizations and mode of deposition. This is a different point of view than used under the Folldal project when most weight were laid upon geophysics, combined with geochemistry.

This work delimit the targets first found from the airborne survey: Mineralizations in some of the old grids are clearly related to graphite zones.

Figure 1 shows the targets which have been found from the airborne survey and are left over after study of the ground data. Those which have been worked on in connection with the Folldal Project are marked by a grid, while the new ones are circled in. Table 1 shows the priority of the targets with respect to further work, what is known about them and suggestion of further work. The new targets have been given lowest priority, because of shortage of time. Even though, mapping is recommended in these areas, to try to find if it should be favourable rocks or even mineralizations.

The mineralization at Sivilvangen mine.

The Sivilvangen (or Auma) mine is found near 0 NS, 0 EW on the Sivildalen grid (N-81-1 project), see fig.2.

Earlier work.

The mine consists only of two sinks, the deepest worked to about 50 m vertical depth. This work was done around 1920 after investigations involving digging and diamonddrilling (8 holes). The drilling showed the mineralized zone to be about 400m along strike and depth at least to 160 m. The average thickness was found to be about 1 m (0.15-2.0 m). This gave a minimum of 220000 t ore assaying 1.7 % Cu and 28 % S (Zn was not analyzed).

TABLE 1.

1.Target: Sivilvangen mine
Description: Sivildalen grid (ca.0NS,0EW). Earlier work by Orkla A/S: EM,mag,VLF,CP,drilling. Very rich Zn-Cu impr over an average of 1.4 m thickness to at least 150 m depth (Cu 1%, Zn 3.5%).
Suggested work: Drilling. 3-6 holes = 450-1300 m.

1.Target: Svartåsen.
Description: Sivildalen grid (3000-6000N,0-800E). Earlier work: EM,VLF,Apex,mag,soilsampling,drilling,mapping. Massive sulfides (Zn-Cu rich) in prospects, extensive alteration, very positive geochem.
Suggested work: Mapping,IP? followed by drilling. 3 holes = 250 m.

1.Target: South of Svartåsen.
Description: Sivildalen grid (ca.2800N,0EW). Earlier work: as at Svartåsen. Possible feederzone,Cu-rich min. Extensive alteration.
Suggested work: Mapping and drilling.1 hole = 190 m.

2.Target: Vardtjønn area.
Description: Vardtjønna grid. Earlier work: Mapping,EM,VLF, mag,IP(limited),soilsampling,drilling. Massive sulfides Zn-Cu-rich in N and E part of grid,extensive alteration very positive geochem.
Suggested work: CP,drilling,(soilsampl.,VLF?).3 holes=350 m.

3.Target: Nonsvola.
Description: Nonsvola grid. Earlier work: Mapping,EM,VLF, mag,soilsampling,drilling. Extensive alteration, positive geochem.,rich Zn-Cu-impregnation.
Suggested work: IP?,drilling,(VLF,soilsampl?).2 holes=220 m.

4.Target: Tonnvola-Fådalen.
Description: Partly Tonnvola and Fådalen II grids. Most interesting area between grids. Earlier work: Mapping, EM,VLF,mag,Apex,soilsampling,drilling. Weak py- and sl-cpy-impr.Possible extensive alteration and vicinity to volcanic center.
Suggested work: Mapping,possibly followed by IP or drilling.

5.Target: Vangrøftdalen-Langen.
Description: 8 grids. Earlier work: Mapping,EM,VLF,mag,soil-sampling,drilling. Possible vicinity to volcanic center. Mine with Cu-mineralization (Fredrik IV).
Suggested work: Geophysics,soilsampling,mapping, rock-samples from mine (analyzed for Au, Ni).

6:Target: Tunndalen,Vesleåsen,Fådalen,Folla.
Description: New targets. Anomalies (geophys./geochem) and possible vicinity to volcanic center.
Suggested work: Mapping given highest priority, followed by soilsampling and geophysics (VLF?).

The ore was found to be of a rich impregnation type in quartz.

New investigations were done by Orkla Mining Company in 1953. This work included geophysics and more drilling. Electromagnetic measurements were done over an area 4 km long along strike of the known mineralized zone (1300 m south and 2700 m north of the deepest sink). A lot of strong conductors were found, of which the longer were found to be graphite related. By comparing the geophysics with mapping done by Folldal Verk A/S, this is confirmed. Also most of the shorter and weaker conductors can be seen to be situated within phyllite units in the area. The ore zone appears as a weak conductor which can be followed discontinuously for about 650 m along strike.

Most of the material from the drilling is lost, but some disappointing analyses and profiles are left from the central part of the ore. The best section gave 0.51 % Cu and 18.4 % S over 3.5 m (Zn not analyzed).

Orkla Industrier A/S was back in the area in 1974 and did CP-measurements on the ore (NGU did the measurements). From this measurements NGU found the areal extent of the ore to be 80000 +/- 30000 m2 (length x depth = 500+/-50 x 160+/-40 m). Some random samples from the dumps gave an average of 1.9 % Cu and 4.1 %.

Diamond drilling were performed by Orkla Industrier A/S in 1975 to find the extent, thickness and content of basemetals in the ore. 13 drillholes were drilled such that they gave five profiles at right angle of strike over a horisontal distance of 500 m.

The mineralization is reported to be a coarsegrained impregnation in mostly quartz, albite and sericite (finegrained muscovite). The important ore minerals are pyrite, sphalerite and chalcopyrite, while galena is very subordinate.

From the drilling it can be seen that the mineralized horizon strikes nearly constant N30oE and dips between 50o and 60o westwards.

The thickness of the orezone was reported to be between 1 and 2 m and assaying ca. 1% Cu and 3.5% Zn in the two central profiles. The length of mineable ore was found to be about 250 m (total length at least 500 m, but wedging out in both ends). One hole (no.13) which hit only 0.2 m impregnation at about 135 m depth along strike was supposed to delimit the ore at depth. A calculation then gave a total of less than 100000 t of ore.

Interpretation.

As will be shown, the ore is not at all delimited: Fig.3 shows a profile parallell to strike of the ore, where the content of S, Cu and partly Zn have been plotted. The data in the profile are from intersections in drillholes drilled ca.1920 and 1975. An isopach-map has also been created (same profile,fig.4). Both these figures indicates that the ore has a very distinct drag southwards: Between DDH 10,12 and 13 from 1975 there is an open space. Holes from 1920 give indications of a continuation of the ore downwards and southwards in this space. for example DDH 8

from 1920 intersects 1.60 m "kis" (not analyzed) at 158 m depth along strike.

From the isopach-map the amount of possible ore down to 160 m depth along strike can be calculated: Average thickness x area of ore x specific weight = 1.4 m x 38400 m2 x 3.5 = 190000 t of ore with content Cu + Zn > 3 %.

Fig.5 is a profile perpendicular to strike of the ore at the intersections of DDH 1, 2 and 3 (1975).

Geology and mineralization.

The mineralized horizon is situated in a sedimentary and tuffitic environment. The rocks are banded chlorite schists (rich in carbonate), quartzofeldspathic scists (muscovite rich) and graphitic phyllites. Felsic and mafic volcanics are very subordinate in this area.

The mineralization are found intercalated in a thick sequence of mafic tuffite (chlorite schists). As mentioned above the mineralization is reported to be a coarsegrained impregnation in mostly quartz, albite and sericite.

Judged from the drill logs (Lysholm 1976, Orkla report) there seems to be no wall rock alteration in connection with the mineralization. (because the mineralized sections of the cores probably are lost, this could not be checked, however). Instead it seems to be an abrubt transition from greenschists to the impregnated quartzrich rock.

Because of the impregnated nature of mineralization, lack of wall rock alteration and also stringerzone, a distal deposition of the sulfides is suggested. The source might be found further north in the area (see later).

Recommendations: Drilling is strongly recommended to find the quality and extent of mineralization at depth. A suggestion is first to drill one hole to hit the ore zone at about 200 m depth along strike below DDH 9,10-1975 and 8-1920 (see figs.3,4)

If this turns out negative a new hole should be tried in the same profile to about 100 m depth along strike. This to make sure that the ore is delimited southwards. If this hole also is negative, one last hole should be tried to about 150 m depth along strike below DDH 1,2,3-1975.

If either of the two first holes proves positive, a drillhole splay of 3-4 holes must be set 100150 m south of the first holes (i.e. in the vicinity of DDH 11,12-1975, but deeper). The results of this splay should give a firm basis for eventual further work.

The Svartåsen area.

This area is situated between the hills Bjørkåsen and Svartåsen, in the structurally upper part of the Hersjø Group, 4-5 km north of the Sivilvangen mine. The rocks in the area are quartzkeratophyre, greenschists and partly graphitic phyllites.

Regional geophysics. (Airborne survey; mag,VLF,EM, map 1:50000) A break in a long formational conductor shown to be graphite, together with a magnetic low makes this area interesting. THe break is short (only 1 km) and might be related to hydrothermal activity.

Regional geochemistry. (Stream sediments-NGU report no.760,1968). Extremely high values for both Cu (<=335ppm), Zn (<=1323ppm) and Pb (<=40ppm) in the drainages from this area are in favour of a larger sulfide deposit. In fact, the values are as high as those which is found in the drainage from the Sivilvangen mine.

Earlier work.
The area is covered by the long Sivildalen grid (3000N-6000N) established in connection with the N-81-1 project (see fig.2). Work in this area includes geophysics (mag,VLF,CEM,Apex), soil-sampling and mapping. Drilling was done in 1983 (5 holes), partly with encouraging results (see later).

Geology.
As mentioned above, the geology comprise quarzkeratophyre, greenschists/-stones and graphitic phyllites. In reality the volcanics often are tuffites.

The geophysical data correlates rather good with geology: EM outline the graphitic horizons very well, high magnetics are measured over the greenschists and phyllites, while low magnetics are found over felsic volcanics.

Conductors are not found in the keratophyre unit south of 5900N, 0 EW. This may point to proximity to a volcanic center. But north of this point a lot of conductors are found in the keratophyre. These are found to be mostly related to graphite and is therefore indicating a tuffitic origin in this area or perhaps are the graphite separating different volcanic flows.

Repetition of rock units in the area is likely due to isoclinal folding. The axis must then be relatively flatlying (gently southward plunging ?).

Mineralzations.
Six small prospects with pyrite +/- sphalerite and chalcopyrite are found between 3800N and 5600N, situated in felsic tuffite. Pyrite disseminations can be seen throughout this area. Both prospects and disseminations are mostly found on the eastern flank of the thick keratophyre unit along baseline. THe rocks in the area are altered to quartz-sericite schists, partly chloritic (according to drill logs).

The richest mineralizations (to date) are found along a graphite horizon extending from 4800N, 0EW to at least 5800N, 100E. Here rock assays from a prospect (5500N,50E gave 2.4 % Cu, 8.2 % Zn, 2.0 % Pb. An even richer richer sample found 50 m north

of this prospect gave 2.1 % Cu, 30.9 % Zn and 14.9 % Pb! Two drillholes at 5600N along strike however, intersected only weak mineralization (0.67 % Cu, 0.89 % Zn, 0.47 % Pb) over 1 m. Two other drillholes in the southern continuation of this zone (5200N) gave at best 10-15 % sphalerite (not analyzed) over 2 m, but weakening at depth. Thus it seems that this mineralized zone is wedging out downwards.

Interesting pyrite-sphalerite-chalcopyrite mineralizations are found in the area between 3900N-4500N and 0-100E. two prospects are also found. Little is known about this mineralized area.

As mentioned, the numerous graphitic zones in the area are easily picked up by geophysics. This makes it difficult to find conductors related to sulfides. Geochemistry (soilsampling) combined with geophysics, however, are outlining promising areas (see later).

Magnetite is found in a keratophyre unit between 3800N and 4400N, 200-250E. This coincides with a very high magnetic area between 3600N and 4800N, 200-350E. This large magnetite horizon probably reflects the distal oxidized part of the sulfide deposit.

Recommendations.
The many positive indications of a larger mineralization demands further work in the area:
a) Extremely anomalous soil in area still not properly investigated.
b) Extensive hydrothermal activity, as shown by wallrock alteration.
c) Sulfides, though mostly disseminated, are found over a large area.
d) Magnetite horizon may be a distal part of a larger deposit.

Follow up:
1. The mineralized area 3900-4500N, 0-100E should be investigated. Soilsamples gives very strong Cu-Zn-Pb anomalies in the area. Drilling is recommended, but thorough mapping and possibly IP should be used to find the best drilling spots.

2. Correlation between geochemistry and geophysics over a keratophyre unit from 4800N,500E to 6200N,800E makes this an interesting target. Sparse pyrite disseminations are found and one prospect are found at 5000N,460E. This was drilltested 1983 and gave 1030 ppm Zn over 0.5 m. The stronger soil anomalies are however found further north (around 5800N). Suggestions for work are mapping and IP to find possible drilling spots.

The connection between the mineralized areas on the Sivildalen grid.

There are two main mineralized areas on the Sivildalen grid, namely Svartåsen and Sivilvangen. The question of connection between these areas 4-5 km apart is of course of great interest.

There are differences between the mineralizations: 1) The mineralization at Sivilvangen is situated in mafic tuffites, while at Svartåsen the mineralization are found in felsic rocks of either tuffitic or volcanic origin. 2) Extensive wallrock alteration is found in the Svartåsen area, but is lacking at Sivilvangen. 3) The mineralization at Sivilvangen is consisting of heavy impregnation in quartz, while at Svartåsen massive sections are found. Both mineralizations are very Zn-rich however, and have Zn/Cu-ratio much greater than 1.

The abovementioned differences may probably be ascribed to different depositional mechanisms and environments, especially if the feeder area should be the same.

A working hypothesis:
The Sivilvangen mineralization might have been created when a sulfide flow slided down a slope from the feeder area and came to rest in a nearsited basin. this will explain the impregnated nature of the mineralization, lack of alteration and the tuffitic environment.
The Svartåsen mineralization may then represent the part of the same mineralization which was stabilized on top of the hill and on the other side of the vent. The massive character of the mineralization, extensive alteration and felsic environment supports this.

The Zn-rich character of both mineralizations suggests that the sulfides in them must have been crystallized rather late in the sulfideforming processes, in other words relatively distal from the feederzone.

A possible candidate for the feederzone is found between 2600-3000N and 0-200E. This area is unfortuneately nearly completely covered, but Folldal Verk A/S drilled there in 1970 on the background of geophysics. Most of the cores and the drill logs are unfortunately lost. The pieces which remains however (from DDH 179), shows a texture which resembles a stockwerk: 1-3 mm thick quartzveins, partly sericitic with disseminated pyrite and irregularly chlorite-sericite zones with disseminated pyrrhotite and chalcopyrite makes up a network surrounding less altered quartzofeldspathic lenses of 0.1-2 cm size.

Also the analyzes from one of the drillholes (DDH 179) fits the hypothesis of a feederzone in the area: 2.8 % Cu and 1.98 % Zn over 0.85 m, i.e. Cu/Zn = 1.4. Analyzes of Au gave 829 ppb over the same section.

The implications of the above outlined working hypothesis is that the Sivilvangen mineralization probably are not connected to the Svartåsen mineralization, even though both originated from the same vent.

Recommendations.
A suggestion is to look for graded bedding and slumping structures when the new drillholes from Sivilvangen are logged. Such structures are expected if the sulfides have flowed down a slope.

A new drillhole is suggested in the suspected feederzone area, possibly at 2700N,200W and angle 50oE. This hole should be

thoroughly investigated to reveal the nature of the mineralization in this area. If this really is the feederzone then a larger deposit in the Svartåsen area seems more probable.

A thorough geological mapping is essential in the whole grid (i.e. 0NS-6500N) to understand the structure of the mineralizations and the connection between them.

The Vardtjønn area

This area is situated in the structurally lower part of the Hersjø volcanics, in a thick sequence of mixed felsic volcanics and tuffites. Figure 6 shows the geology in the area taken from Bjerkgård (1989).

Regional geophysics. (Dighem 1:20000).
A lot of strong and long conductors are wedging out into a high resistivity area. The magnetics are partly high. Fieldwork have shown the conductors to be graphitic. High and low magnetics north of the conductive area correlates to greenstones and felsic volcanics, respectively. Also a central zone within the conductive area shows high resistivity/low magnetics and is shown to correspond to felsic volcanics/tuffites and in the south a gabbroic body.

Thick volcanic sequences, especially felsic, combined with wedging-out of graphitic horizons indicates a volcanic center. This is as mentioned before a favourable place for massive sulfide deposits.

Satellitic conductors in the northern part of the conductive area is shown to coincide with graphitic zones and partly with small sulfide occurrences.

Regional geochemistry. (Stream sediments-NGU report no.829,1969).
Cu - Anomalous in lower part of Vardtjønnbekken and in Røstesbekken (south of Vardtjønnbekken).
Zn - Very high values in lower part of Vardtjønnbekken (<=630ppm) Slightly anomalous in Storbekken. Anomalies in upper part of stream may be due to the Nonsvola mineralizations.
Pb - Very high values in Vardtjønnbekken (30-33ppm),highest in lower part.

The reason for higher values in the lower part of Vardtjønnbekken may be due to a massive py-sl-cpy mineralization found in the stream (see later).

Earlier work.
One grid was established in the area in connection with the N-81-1 project. The area was covered with geophysics (CEM,mag,VLF and at some spots IP), soilsampling and also geologically mapped (300S-2100N). Four drillholes were drilled on the basis of Cu-anomalies in soil and geophysics in the southern part of the area (0NS-500N). The results of the drilling were negative (graphite, pyrite-pyrrhotite disseminations).

Geology.
The area covered by the grid is dominated by quartzkeratophyre (volcanic/tuffitic) in the northern part (500N-2100N) and a

metagabbroic body south of 500N. Tuffitic greenschists are found in eastern part of grid (mapped 300S-1100N,250E-450E). A lot of trondhjemitic bodies are found in the keratophyre unit, often associated with phyllitic and graphitic horizons. These horizons show up very well on geophysics.
NB! It should be mentioned that this description is taken from Bjerkgård (1989) and differs somewhat from the mapping done by Folldal Verk A/S.

Mineralizations.
It is found nine small prospects in the area, one of them a graphite prospect. Five of the prospects, which lies close to baseline, is situated in a quartz-sericite schist horizon. The horizon, which is mapped between the two streams Storbekken and Vardtjønnbekken, makes out an antiformal structure and the mineralizations are situated on the flanks of this structure (see fig.6). Bjerkgård (1989) showed that the quartz-sericite schist is hydrothermally altered quartzkeratophyre.

At 1700N/10W there is a very interesting massive pyrite-sphalerite-chalcopyrite mineralization (massive ore found at dump),but perhaps of limited thickness. The other mineralizations in the altered horizon consists of disseminated pyrite and may be distal facies to the massive mineralization.

The two mineralizations at 710N,90E and 810N,130E are of little interest, as they are consisting of disseminated sulfides in quartz-sericite schist xenoliths in trondhjemite.

A 30 cm massive pyrite-sphalerite-chalcopyrite mineralization is found in Vardtjønnbekken at about 750N,500E. This is outside the area mapped by Folldal Verk A/S. The mineralization has much in common with the deposit at the Vingelen mine. It is situated in chlorite schists (tuffite) and has the same delicate banding as the Vingelen deposit, between py-cpy and sl-py bands. Another interesting moment is that pure gold (size 1-60 microns) is found in a 1 cm thick cpy-rich zone in this mineralization (Bjerkgård 1989). Because of very limited wallrock alteration a distal deposition is suggested (like the Vingelen deposit).

Even though there are problems concerning the numerous graphitic rocks in the area, the richer mineralizations seems to give weak but rather distinct response on geophysics, especially VLF. The massive mineralization at 1700N/10W has a corresponding conductor which can be followed from 1400N,25E to 1900,100W and probably 2200N,150W. Pyrite-sphalerite dissemination in sericite schist are found in the stream (Storbekken) at 2050N,100W and a prospect with pyrite dissemination is found at 2090N,100W. The conductor also coincides with the strike of the rocks.

The massive mineralization at 750N,500E gives a very weak response on the VLF, which can be followed from 700N,500E to 1000N,450E.

Also the border between the pyrite-impregnated sericite schist zone and the massive volcanogenic keratophyre east of it can be seen on the VLF in the southern part,i.e. 800-1200N.

Recommendations.
More work in this area is highly recommended. Extensive wallrock alteration and massive sulfide horizons are found in the area and demands to be followed up. The work should be concentrated on the two massive mineralizations.

1. Mineralization at 1700N,10W.
- The massive mineralization is only found at the dump. It should be searched for. Trenching in the bottom of the existing blast pit seems the easiest way.
- CP should be tried if the massive part is found or perhaps better in a drillhole intersection.
- Drilling is recommended through the whole quartz sericite horizon. This to find where the horizon is mineralized (both flanks ?) A suggestion for drillspot is 1800N,120W (220 m to drill), because VLF shows better response northwards.

2. Mineralization at ca.750N,500E.
- Because of very good outcrop in stream, CP is recommended.
- One short drillhole (50 m ?) could be tried to outline extent in depth.

An anomaly from the Dighem survey is found at about 1470N,450E. This is along strike from the abovementioned mineralization. It should probably be searched for by soilsampling and VLF.

Nonsvola.

The Nonsvola area is situated in the Hersjø volcanics, near the contact to the Gula sediments. Fig.7 shows the geology in the area, taken from Bjerkgård (1989).

Regional geophysics (Dighem 1:20000).
The Dighem survey reveals two shorter satellitic conductors immidiately south of a main formational conductor. Fieldwork have shown these to be graphitic horizons. Generally low magnetics and high resistivity in the area coincides with mainly felsic volcanic and tuffitic rocks. Higher magnetics further east coincides with a massive greenstone unit.

Regional geochemistry (Stream sediments-NGU report no.829,1969).
Slightly anomalous Cu and Zn and anomalous Pb are found in the streams draining the western slope of the mountain.

Earlier work.
One grid was established in the area in connection with the N-81-1 project. The area was covered with geophysics (CEM,mag), soilsampling and also mapped. Five diamond drillholes gave negative results. The area is also discussed in Cand.Scient. thesis by Bjerkgård (1989).

Geology.
Quartzkeratophyre, both of volcanic and tuffitic origin dominates the area, together with mixed mafic-felsic tuffites (see fig.7). Subordinate are phyllitic and graphitic horizons, trondhjemite and mafic tuffites. Massive volcanic flowsshows that this area must be close to a volcanic center.

Four small prospects are found near N1100,150E. Mineralizations consists of pyrite, partly massive with subordinate pyrrhotite, sphalerite and chalcopyrite. The felsic rocks in the area are extensively altered to quartz-sericite schists, in the prospects also to quartz-chlorite rocks and quartzites. this implies a high hydrothermal activity and a possibility for a larger massive sulfide deposit.

One horizon of quartz-sericite schist extends from the three westernmost prospects and southwards to 300N,B.L. This horizon coincides with high Cu,Zn,Pb values in the soil and also partly with CEM. Py-sl-cpy-po mineralization is found at 350N,B.L. where the soil values are highest. Another zone extends northwards from the eastern prospect to about 1500N where pyrite mineralization is found. Soilsampling has not been done in this northern part of the grid (1100-1500N) but the zone coincides with CEM. The two zones may be connected because of isoclinal folding.

Recommendations.
The Nonsvola area should be investigated further. The proximity to a volcanic center, high hydrothermal activity and very positive base metal anomalies in soil makes the area still an attractive target.

1. It is suggested that the activity is concentrated to the two abovementioned hydrothermal zones (300N,B.L-1100N,150E and 1100N,175E-1500N,175E).
2. Because the mineralizations seems to be rich in sphalerite, an

IP survey should first be tried on both zones. But graphite may affect the measurements.

3. Drilling is suggested to check the zone from 300N,B.L-1100N,150E, perhaps at 500N,50W. The other zoneshould also be drilled if IP turns out positive.
4. High Pb in soil 0-200N,250W coincides with another hydrothermally altered zone. This zone extends southwards out of the grid and sparse pyrite disseminations are found. The grid should therefore be extended southwards and VLF and soilsampling should be done (perhaps also magnetics), together with geologic mapping.

The area Fådalen-Tonnvola.

The area is situated in the structurally higher part of the Hersjø volcanics, in this area dominated by greenschists and quartzkeratophyre. Fig.8 shows the geology in the two grids in the area.

Regional geophysics. (Airborne survey;EM,mag,VLF-map 1:50000). A long formational conductor shown to be graphite is wedging out northwards in this area. The magnetics is very low and corresponds to felsic volcanics.

Regional geochemistry. (Stream sediments-NGU report no.829,1969). Drainage from Tonnvola gives slightly anomalous Cu and Zn and anomalous Pb. Drainage from Fådalen gives background values for Cu, Zn and only slightly anomalous Pb.

Earlier work.
The area comprise two grids from the N-81-1 project, Tonnvola and Fådalen II. Both grids have been covered with geophysics (CEM,mag,VLF), soilsampling and also mapped. One drillhole in the Tonnvola grid gave negative result (graphite with pyrite and pyrrhotite impregnations).

Geology.
The rocks in the area are are dominantly quartzkeratophyre and greenschists (see fig.8). Between the thick units of possible volcanic origin, there is a thick graphite horizon, wedging out in the Tonnvola grid (the formational conductor on the airborne survey). The graphite horizon shows that the greenschists and keratophyre are belonging to two different volcanic epochs. the graphite also shows a reducing environment, favourable for sulfide deposition.

The thickness of the felsic volcanics increase northwards. This together with wedging out of the graphite, makes a volcanic center in the north possible.

Mineralizations.
Sulfides - dominantly pyrite disseminations with subordinate amounts of sphalerite, chalcopyrite and galena is found in a thin horizon of possibly altered quartzkeratophyre (sericite schist in drillhole Tonnvola), in close contact to the graphitezone.

Rocks mapped as quartz-mica schists and mica schists immidiately east of the sulfidezone, may represent hydrothermally altered rocks (quartz-sericite schists) in connection with the sulfides.

If the mica schists are representing altered rocks, then the richest mineralization might be found between the two grids (about 600 m between grids). Indications are that a small prospect on the Tonnvola grid (near 100N,400W) contain Zn,Cu, while a mineralized outcrop on the Fådalen grid (1100N,175E) is rich on lead (Pb is usually the last element to drop out of solutions). Some scattered high Zn, Pb and Cu-anomalies in soil downdrainage from the supposed mineralization in the Fådalen grid, are also positive indications.

Recommendations.
The possible vicinity to a volcanic center makes this area still an attractive target.
1. The mica schists should be investigated to find whether they are hydrothermally altered quartzkeratophyre (= quartz-sericite schists +/- chlorite).
2. If altered rocks are found, then the area between the grids should be mapped and soilsamples taken to outline anomalies.
3. IP could be tried, but the many graphitic zones in the area would probably destroy the weak anomalies from sulfides. Drilling is perhaps better at once.
4. If the mica schists does not represent altered volcanics, the area should be dropped. Disseminated sulfides are nearly always found in the vicinity of graphitic schists.

The area between Vangrøftdalen and Langen.

Regional geophysics.
From the geophysics the area between vangrøftdalen and the lake Langen looks very interesting: A lot of strong conductors can be seen wedging out into a low magnetic and high resistivity area between the lakes Stortjønna and Blestertjønna. As was pointed out in the introduction, this combination may be representing a volcanic center, which is a favourable site for massive sulfide deposits. Fredrik IV's mine is situated in this area and also some small mineralizations (described later).

Regional Geochemistry. (Stream sediments-NGU report no.829,1969)
The stream storbekken which drains the lake Stortjønna, is showing high Cu-values. Zn and Pb are relatively low, but above background. Anomalous Pb-values are observed in an area southwest of Storbekken (ca.1 km along strike).

Earlier work.
The area Djupsjøen-Langen-Vangrøftdalen comprise eight grids from the N-81-1 project: Djupsjøen, Grue, Nordervollen, Nyås, Vangsåsen I og II, Skogli and Vangrøftdalen. Fig.9 shows the locations of the grids and geology in the area.

With exception of Nyås and Grue, the grids are covered with geophysics (VLF,CEM,mag), soilsampling and also geologically mapped. The grids Nyås and Grue have only partly been covered with geophysics and soilsampling. Diamond drilling in the grids Nordervollen (3 holes) and Djupsjøen (1 hole) have been negative.

Geology.
The western part (from Djupsjøen to Vangrøftdalen) which comprise the grids Djupsjøen, Nordervollen, Vangsåsen II and Vangrøftdalen, are relatively well mapped. Greenstones

(metabasalts?) and greenschists (metatuffites?) are dominating rocktypes. Subordinate are gabbroes, trondhjemites, phyllites and quartzkeratophyre.

The eastern part of the area, covered by the grids Grue, Nyås, Vangsåsen I and Skogli, is only mapped in the vicinity of the river Vangrøfta. The rocks are greenschists, phyllites and graphite.

Mineralizations.

Some poor sulfide mineralizations can be found within the greenschists (grid Nordervollen). They seems to follow graphitic zones within the schists. One exception is perhaps a mineralization found in a prospect in the Nordervollen grid at 2200N,25E. The mineralization is situated in micaschist, probably quartz-sericite schist and has associated quartzite. If the mica schist and quartzite are hydrothermally altered rocks, a larger mineralization may be found at this place. A drillhole drilled 50 m southwest of the prospect intersected mineralized quartz-chlorite schist with up to 1200 ppm Cu and 4000 ppm Zn.

A possible graphite-pyrrhotite horizon (VLF,CEM,mag-anomaly) is wedging out eastwards in the grid Grue. Fredrik IV's mine is situated in the continuation of this horizon along strike. This is a Cu-rich deposit situated on top of a leucogabbroic body in close association with pale green phyllites (Cuttle 1983). A series of NW-NNE fractures can be seen mineralized with copper along with quartz-carbonate-tremolite-assemblages (op.cit.). Fuchsite is closely associated with the overlying phyllites (op.cit.). The relation between the gabbroic body and mineralization is not certain. Nothing is known about the grade of Cu or other elements in this deposit. It is possible that the sulfides have been fractionated from the mafic melt which created the gabbro - a socalled orthomagmatic deposit. If this is so, one should expect high Ni-content.

Recommendations.

More work are recommended in the area, but concentrated to the eastern part, i.e. between Stortjønna and Blestertjønna. Little is known about the area, but regional geophysics are as mentioned showing low magnetics and high resistivity. Also the enigmatic mineralization at Fredrik IV's mine is found in this area.

1. The grids Grue and Nyås should be connected to cover the whole area.
2. Mapping must be done to reveal the reason for the low magnetics and hig resistity. Both felsic volcanics and intrusives are possible candidates, also leucogabbro (as on Gruvåsen). It is important to look for indications of hydrothermal activity.
3. The mineralization at Fredrik IV's mine should be thoroughly investigated to find possible relation between the gabbro and mineralization. Rock samples should be taken and analyzed for Ni, Au and basemetals.
4. Soilsampling, VLF and magnetic measurements should be done in the whole area.

In the Nordervollen grid teh prospect at 2200N,25E shouldbe investigated to find if the micaschists and quartzites are a result of hydrothermal activity. If this is the case, drilling is recommended, after thorough structural measurements to find direction of eventual fold axis.

The area north and south of the river Folla.
(around UTM 950785/mapsheet Alvdal-1619 III).

This area in the Hersjø group is not covered by any grid. A long EM-conductor (airborne survey) near border to the structurally underlying Dalsbygd Group is disappearing about 700 m north of the river Folla, see fig.10. The magnetics are also low in the area. This is symptomatic of volcanic activity.

Drainage south of the river gives anomalous Cu and Pb values (stream sediments - NGU report no.760,1968).

Recommendations: The area should be mapped to find causes for anomalies. Soilsampling and VLF should assist the mapping.

The Vesleåsen area.
(around UTM 795985/mapsheet Alvdal-1619 IV).

This area is situated near the border to the Gula Group, immidiately west and south of the long Sivildalen grid, see fig.10.

Two small pyrrhotite prospects are found immidiately east of the area (2300S,700E and 2500S,700E) in the Sivildalen grid.

The airborne survey are showing a long formational conductor which wedges out northwards. The conductor is situated in a low magnetic area. Slightly anomalous (Cu,Zn) sediments are found in the streams which drains the area.

Recommendations: Mapping should be done in the area to find the nature of this anomal area. Look for felsic volcanics with signs of wallrock alteration. VLF and soilsampling may assist the mapping, especially if the area is heavily covered.

Fådalen.
(around UTM 855075/mapsheet Kvikneskogen-1619 IV).

This area is situated in the Hersjø Group near the border to the structurally underlying Dalsbygd Group, see fig.10.

The airborne survey is showing breaks in long formational conductors about 1.5 km north and south of the river Fåa. The magnetics in the area are low. Some interesting short but strong conductors are found in the valley floor.

Somewhat anomalous Cu and Zn are found in the sediments in the river Fåa downdrainage from the anomalies, but are not easily interpretated. Very high Cu-values caused by the Bjørkåsen-Svartåsen mineralization are found updrainage in the river and may have had influence.

The area is only very superficially mapped in connection with regional mapping. Thick units of greenschists and keratophyre seems to dominate the area.

Recommendations: Possible proximity to a volcanic center makes the area worth investigations. The EM-anomalies may be related to sulfides. Mapping assisted by soilsampling (but be aware of

cultural activity) and VLF seems adequate to reveal the nature of the anomalies.

Tunndalen area.

Three singular, relatively strong EM-anomalies from the airborne survey, are found north of the Tonnvola grid, see fig.10. These have coordinates: UTM 872129, 888139 and 889143 (mapsheet Kvikneskogen - 1619 IV).

Judged from geological map, the first one is situated on the westernside of a thick keratophyre unit, while the other two are situated on the eastern border of the same unit.

Recommendations: The area should be mapped to find the nature of these anomalies. If the area is heavily covered, VLF and soil-sampling should be used. The position near the borders of the keratophyre unit and possible proximity to volcanic center (same as the Tonnvola-Fådalen area) makes these anomalies interesting targets.

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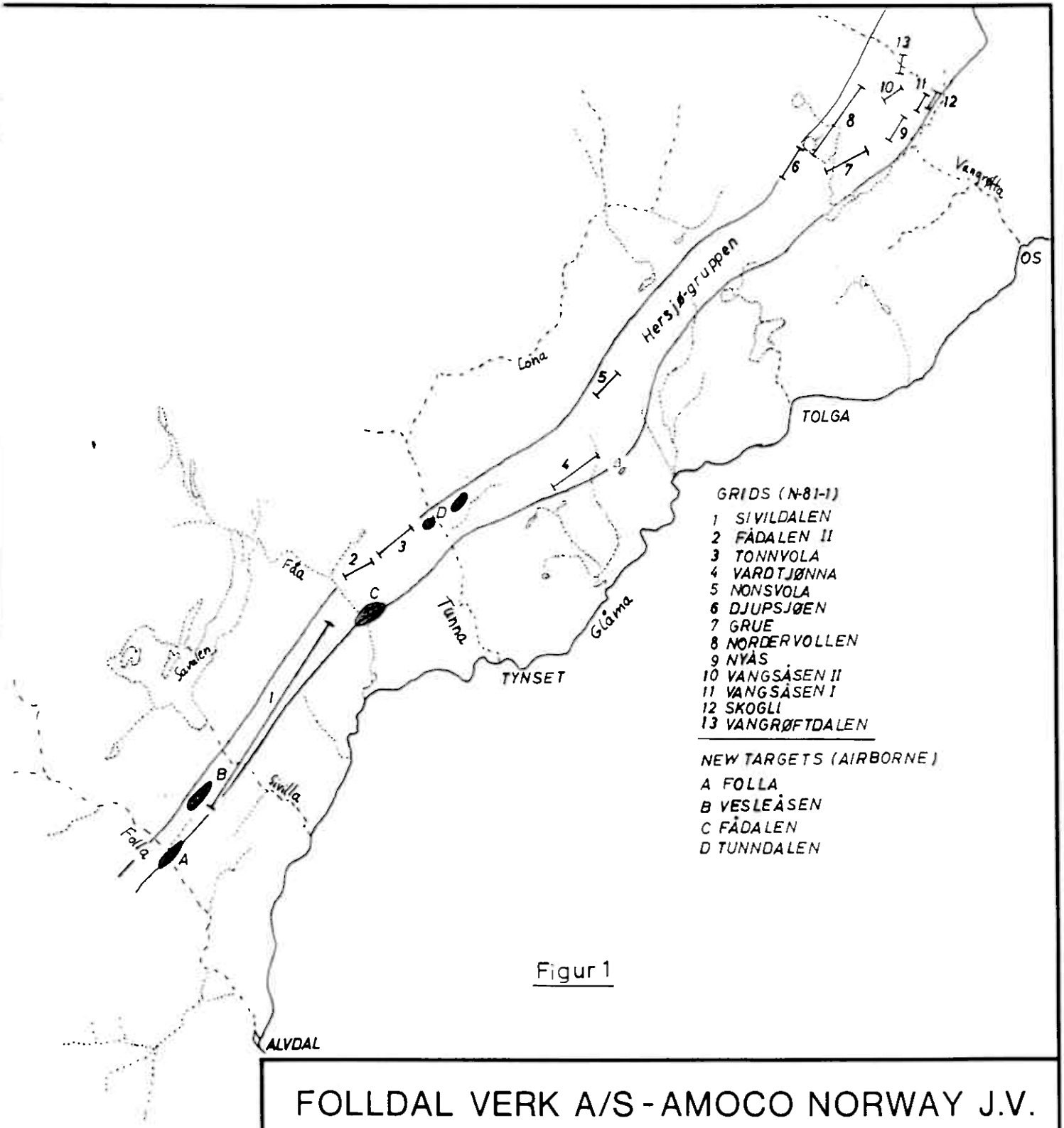
NGU 1968: Oppdrag A/S Folldal Verk. Geokjemiske undersøkelser. Grimsdalen III, Savalen IV. NGU rapport nr.760, Trondheim 1968.

NGU 1969: Oppdrag A/S Folldal Verk. Geokjemiske undersøkelser. Haustsjøen V, Kvikne VI. NGU rapport nr.829, Trondheim, 1969.

The main material behind this report have been the data from the Folldal project. This includes regional geophysics and ground data from several grids (geophysics, soilsampling, mapping and drill logs).

From the Sivilvangen mine area, data and reports from Orkla Industrier A/S have been used, which includes drillhole data and geophysics.



Figur 1

FOLLDAL VERK A/S - AMOCO NORWAY J.V.

PROJECT

LOKALISERING AV OPPFØLGINGSOMRÅDER.

Date 31/1-90	Scale: 1: 250000	CB

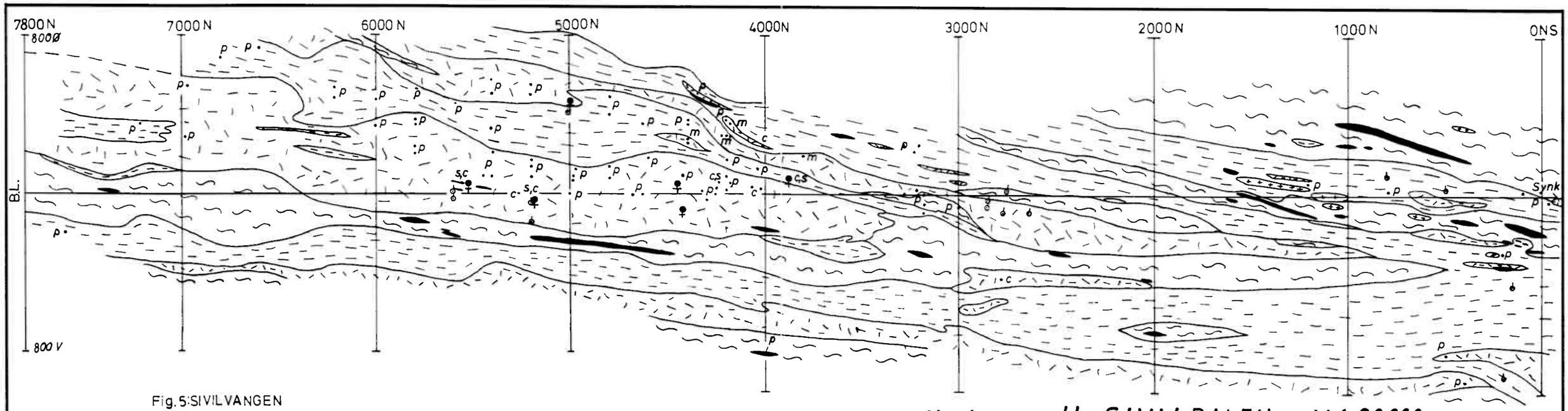
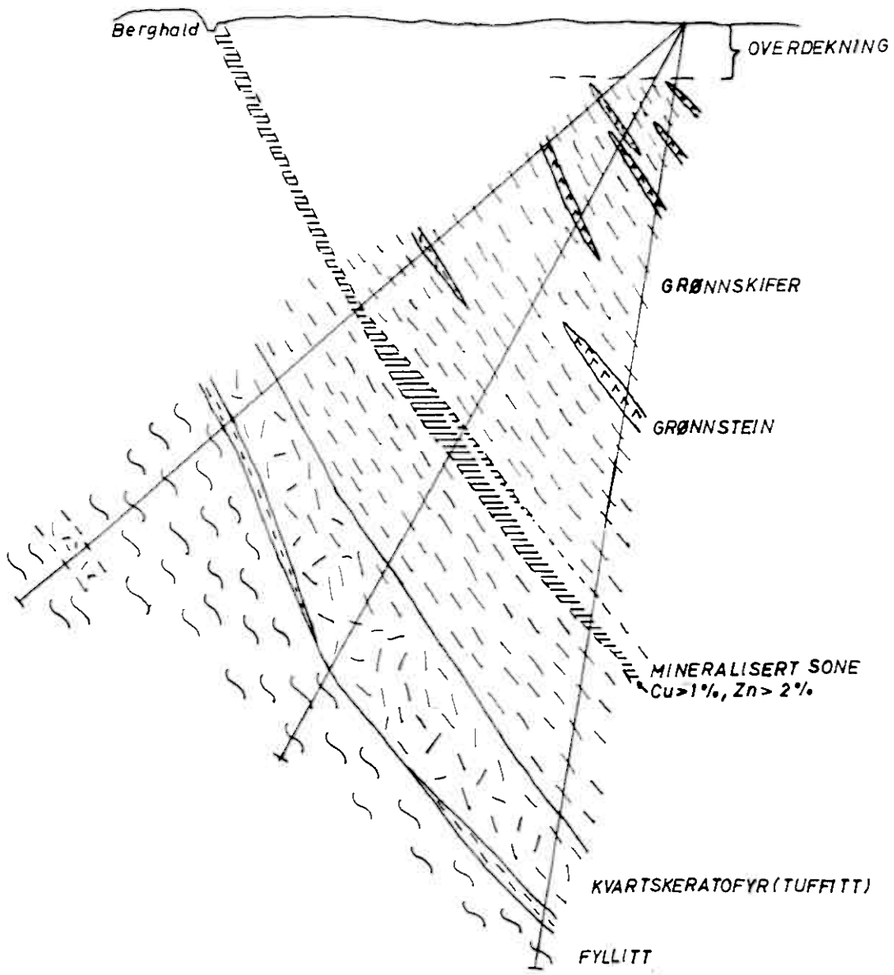


Fig. 5: SIVILVANGEN
PROFIL BORHULL 1,2,3-1975

Fig.2: **stikningsnett SIVILDALEN.** M 1:20000



TEGNFORKLARING

- KVARTSKERATOFYR
- GRØNNSKIFER
- FYLLITT
- TRONDHJEMITT
- GRAFITT
- SULFIDER p = pyritt, c = kobberkis, s = sinkblende, m = magnetitt
- SKJERP
- DIAMANTBORHULL

FOLLDAL VERK A/S - AMOCO NORWAY J.V.

PROJECT

Date	Scale: 1:	

A.S TORRKOPI

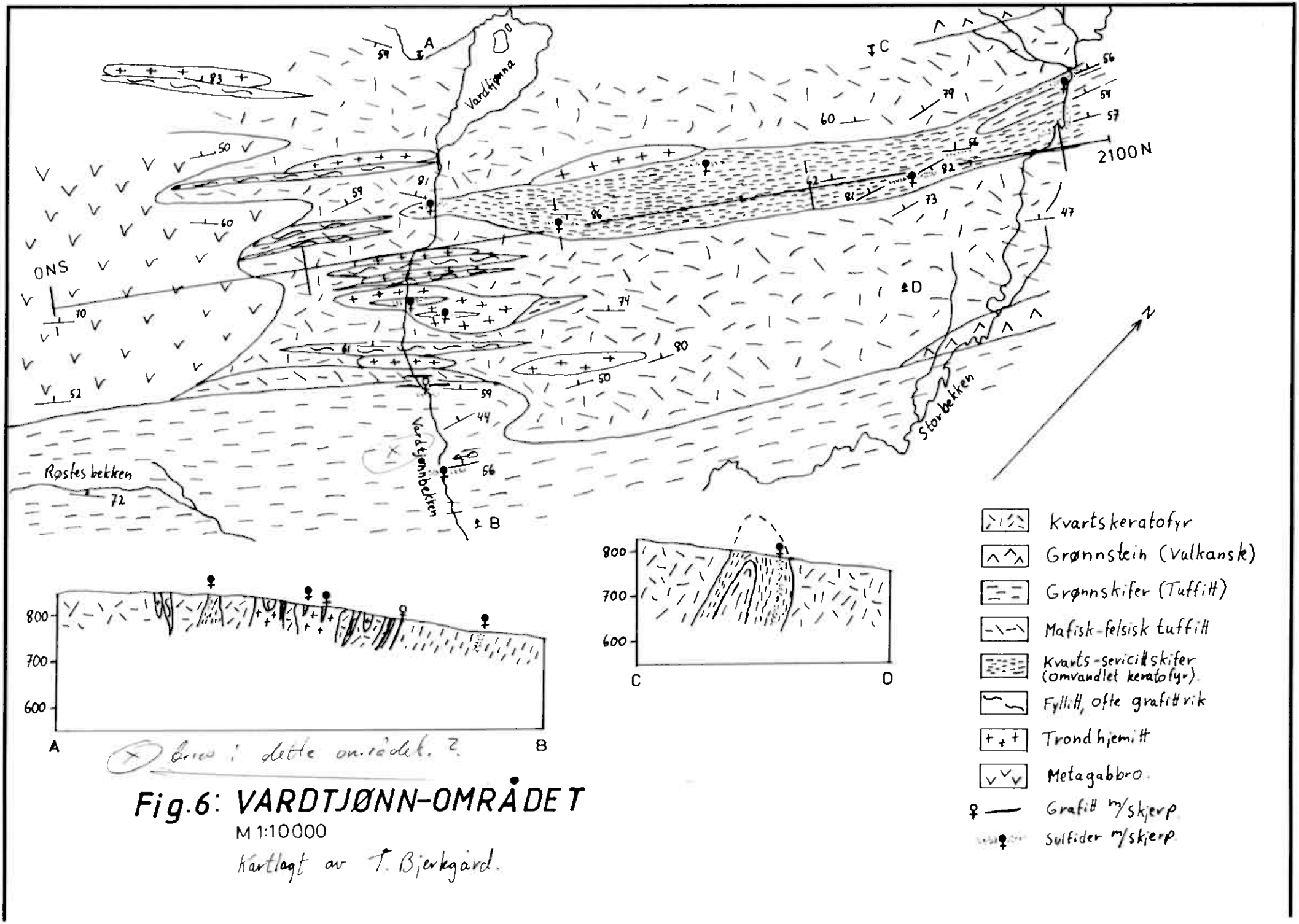
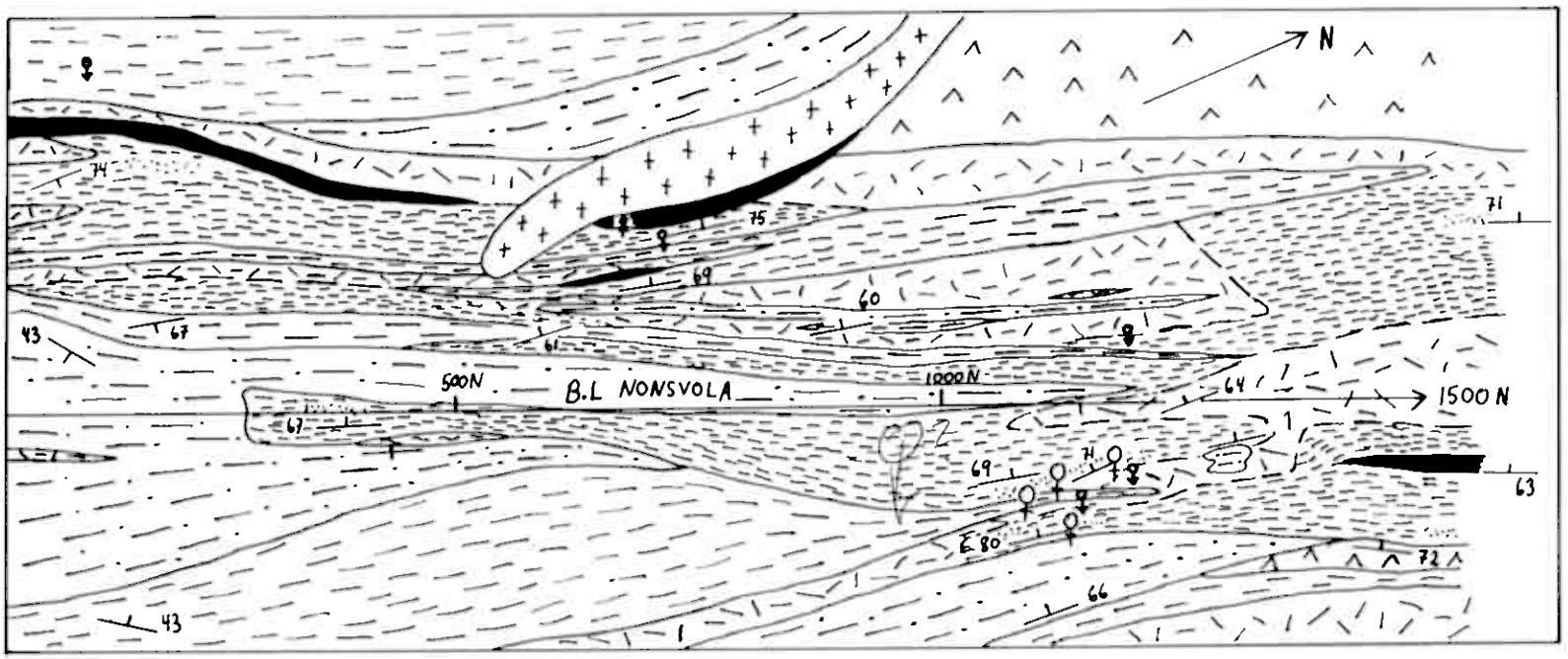


Fig.6: VARDTJØNN-OMRÅDET

M 1:10000

Kartlagt av T. Bjerkgård.

NONSVOLA.



500 m

Bare boring aktuelt?

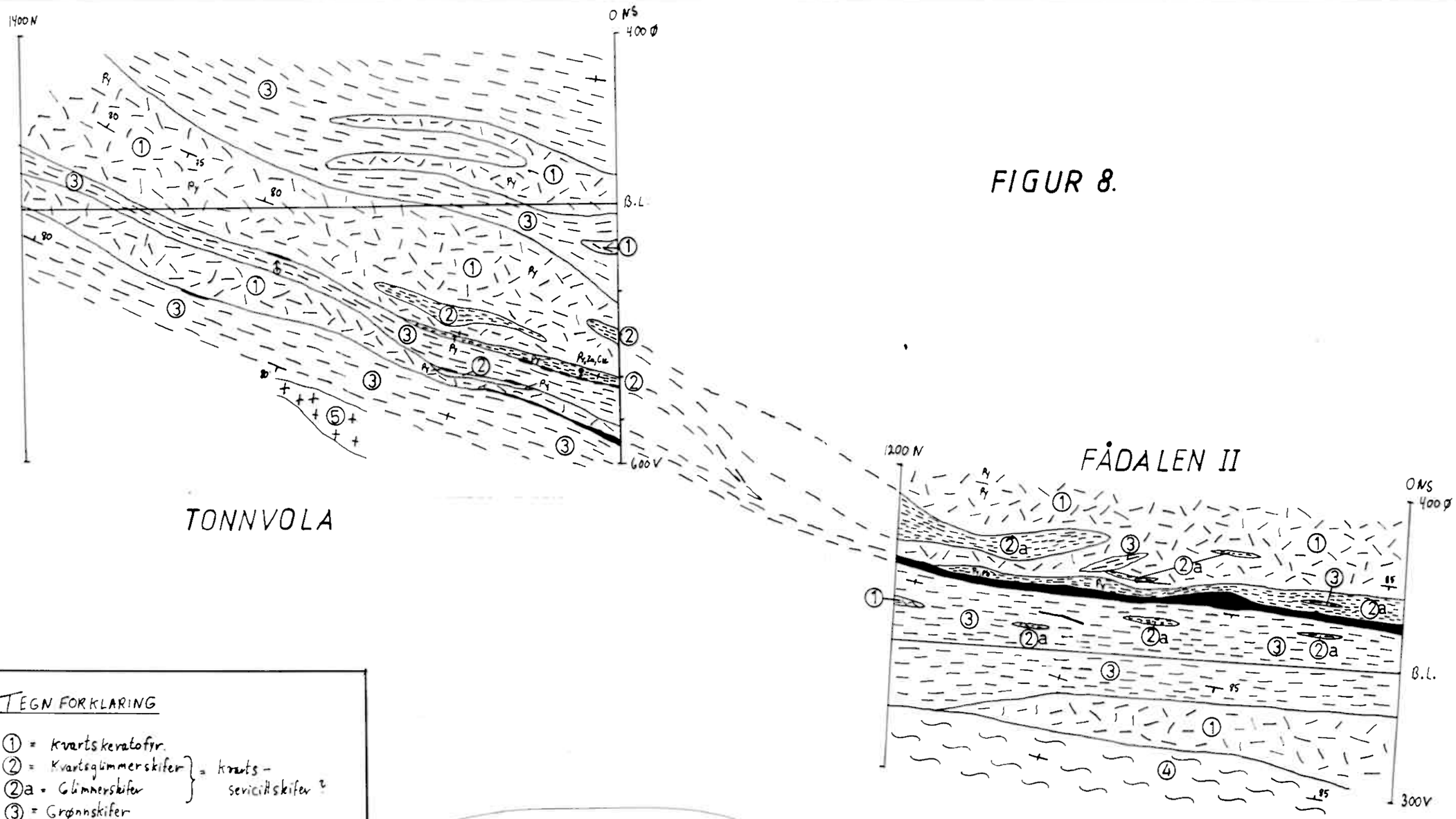
- = Kvartskeratofyr
- = Grønnskein (vulkansk)
- = Grønnskifer (tuffitt)
- = Mafisk-felsisk tuffitt
- = Trondhjemitt
- = Kvarts-sericittskifer (omvandlet keratofyr)
- = Grafittskifer
- = tuffitt (noe grafittisk).
- = Sulfid mineralisering.

- = sulfid skjerp.
- = Grafittskjerp.
- = Diamantborhull.

FIGUR 7.

Kartlagt av Terje Bjerkgård.

FIGUR 8.



TEGN FORKLARING

① = Kvartskeratofyr.
② = Kvartsglimmerskifer } = kvarts-
②a = Glimmerskifer } sericittskifer ?
③ = Grønnskifer
④ = Fyllitt
⑤ = Trondhjemitt
▬ = Grafitt

Skjerp
Diamantborhull.

Py = Pyritt
Pb = Blyglans
Cu = Kobberkis
Zn = Sinkblende

Nærlegge sideskriv om vandling.

FOLLDAL VERK A/S - AMOCO NORWAY J.V.

PROJECT

Sammenstilling av stikningsnettene
Tonnvola og Fåclalen II

Date 10/1 -90	Scale: 1: 10000	03

A.S TØRRKOPI

FIGUR 9.

B.L. Djupsjøen

Store Djupsjøen

B.L. Nordervollen

Nyvollbekken

Flovollbekken

B.L. Vangrøftdalen

Vangsåsen

B.L. Vangsåsen II

B.L. Vangsåsen I

Storflo-tjønna

Vangrøfta

Mosetjønna

Storbekken

Storfjønna

B.L. Grue

Flatskarv-åsen

Fredrik IV's grube

Gruvåsen

Krokfjønna

Langsåsfjønna

Langsåa

Blesterfjønna

B.L. Nyås

B.L. Skogli

Tegnforklaring

① = Grønnskifer
② = Grønnstein (massiv)
③ = Kvartskeratofyr
④ = Fyllitt
⑤ = Glimmerskifer
⑥ = Grafitt
⑦ = Trondhjemitt
⑧ = Gabbro
⑨ = Ultramafitt
⑩ = Kvartsitt

/ / = Bergartsgrenser - sikre / usikre.

~~~ = Geofysiske anomalier

♀ = Diamant borhull

FOLLDAL VERK A/S

PROSJEKT:

DJUPSJØEN – VANGRØFTDALEN
Stikningsnett og Geologi

Date 6/1 - 1990	Scale: 1:20000	TBjerkgård

A.S FORMKOPI
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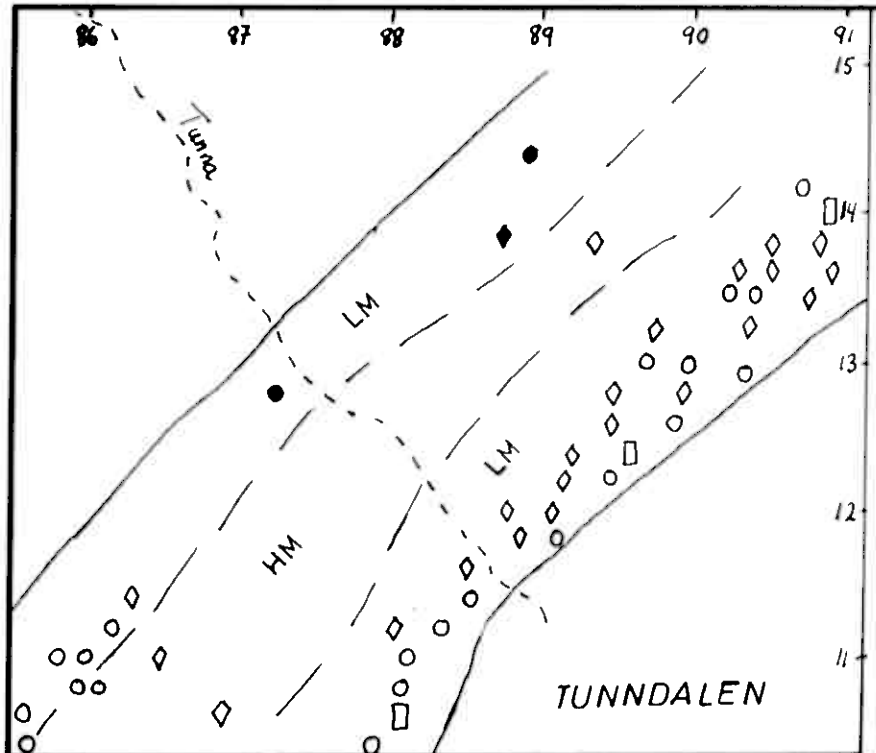

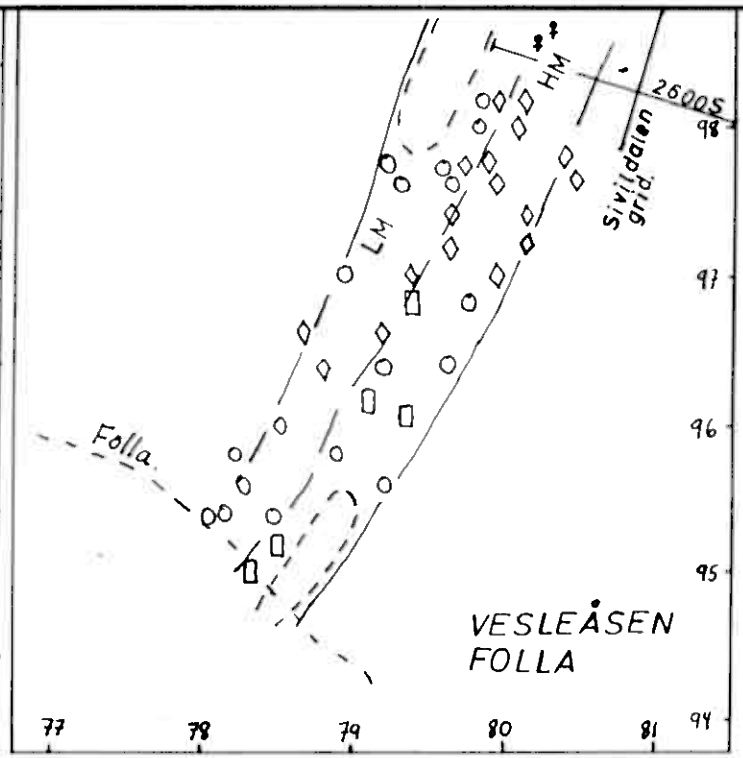

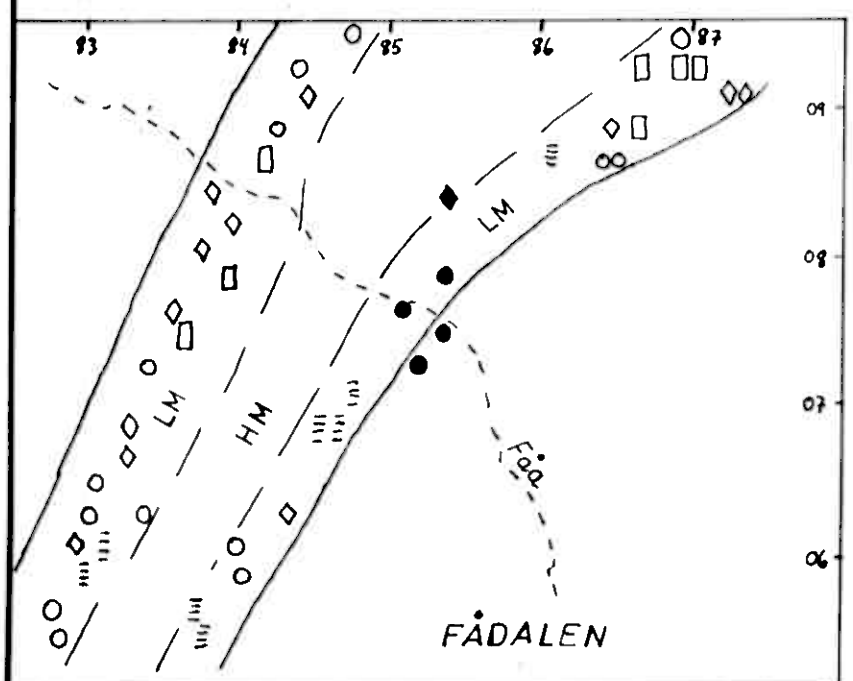

FIGUR 10

GEOFYSISKE ANOMALIER – HERSJØGRUPPEN.
Kartblad 1619 III og 1619 IV. M 1:50000
Helikoptermålinger.

TEGNFORKLARING

□, ◇, ○, ≡ = Ledningsevne – meget god til svak. } EM - TOLKNING
◆, ● = Interessante anomalier.

HM / LM = Høy og lavmagnetisk område.

Anomalt område.

Grenser for Hersjøgruppen.